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Preventing Disability: The Influence Of Modifiable Risk Factors On State And National Disability Prevalence

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ABSTRACT **Disability levels in the United States declined during the 1980s and 1990s, but these declines stalled more recently. Using data for 2013 from the Behavioral Risk Factor Surveillance System, we estimated the percentages of national and state disability that could be prevented through reductions in five modifiable health risk factors associated with disability: cigarette smoking, obesity, diabetes, high cholesterol, and hypertension. Taking into account risk-factor prevalence and the association between each risk factor and disability, we evaluated the fraction of disability preventable if risk factors were reduced under two scenarios: complete elimination of risk factors and reduction in all states to the lowest levels observed in states. If all five risk factors were eliminated, 53 percent of disability could be prevented nationally. The largest contributors were smoking (17 percent), obesity (16 percent), and hypertension (12 percent). If all states reduced risk-factor levels to the lowest observed levels, up to 7 percent of disability could be prevented nationally. Many states in the South and Midwest could experience disability reductions of more than 10 percent by attaining the same risk-factor levels as in states that had the lowest levels. Improved risk-factor prevention could result in the resumption of longer-term declines in US disability.**

Disability is a key indicator of population health.[1,2] It imposes a large burden on individuals and their families, health care expenditures, and economies as a whole.[3–7] While life expectancy in the United States has continued to improve, since the early 2000s the prevalence of key disability indicators among people younger than age seventy has either increased or remained stagnant.[8–11] These indicators include limitations in the activities of daily living (ADL) and instrumental activities of daily living (IADL). The recent patterns are in contrast to remarkable declines in these and related disability indicators during the 1980s and 1990s.[12–15] The reasons why the decline in disability has stalled for large segments of the US population remain unclear.

Five major lifestyle-related factors have been shown in observational studies to increase the risk of disability for individuals: obesity, diabetes, hypertension, high cholesterol, and cigarette smoking.[10,16–18] Aside from their association with disability, these lifestyle-related factors are interdependent. Obesity, diabetes, hypertension, and high cholesterol are cardio-metabolic conditions. All four are influenced by dietary intake and physical activity.[19] Cigarette smoking is a behavioral risk factor that is also associated with cardio-metabolic morbidity as well as cancer. Ample evidence indicates that these risk factors are preventable through lifestyle modifica-

tion.[20–24] Thus, some proportion of disability at the population level could be prevented through populationwide reductions of these risk factors. However, there are no estimates as to how large a reduction in disability we could expect if the five risk factors were reduced to target levels.

Our objective was to evaluate the role of these five modifiable risk factors in contributing to population-level disability prevalence in 2013. We did so at both the national and state levels by using a preventable fraction framework, which allowed us to describe the percentage of disability that could be reduced if a given risk factor were eliminated or reduced.

Study Data And Methods

STUDY DATA We obtained data for 2013 on disability and risk factors from the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is an annual national telephone survey conducted collaboratively by US states and territories and the Centers for Disease Control and Prevention (CDC).[25] It is the only major US health survey that provides representative population-based data at the state level for all states. It collects data on a wide range of health conditions and risk factors, including those related to chronic disease, health care access and preventive screenings, and immunizations. We restricted our analysis to adults ages 18–79 residing in one of the fifty states or the District of Columbia. Of the 443,731 respondents sampled in 2013 who met these criteria, we analyzed the 391,389 respondents who had complete data for our variables of interest (88 percent of the eligible sample). We analyzed 340,280 individuals for estimates regarding high cholesterol, as data on high cholesterol were available only for those who reported having had their cholesterol measured and who had information on other covariates.

STUDY MEASURES We focused on physical disability. In 2013 the BRFSS included for the first time a set of five disability-related questions recommended by the Department of Health and Human Services.[26] We based our definition of *disability* on answers to three of those questions that were pertinent to global physical functioning, and we excluded from analysis data on the remaining two questions, which asked about vision-related and cognitive disability.

The three questions about global physical functioning were as follows: "Do you have serious difficulty walking or climbing stairs?," "Do you have difficulty dressing or bathing?," and "Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?" The first two questions are among Sidney Katz and coauthors' activities of daily living (ADL) limitation items,[27] and the third is conventionally used as a measure of instrumental activities of daily living (IADL) to capture a person's ability to perform key social and economic roles.[28,29] We classified respondents as being disabled if they responded "yes" to at least one of the three questions.

All risk-factor data were obtained from questions asked in the 2013 BRFSS. As noted above, the five risk factors that we examined were cigarette smoking, obesity, diabetes, high cholesterol, and hypertension. Following conventional guidelines, we defined obesity as having a body mass index (BMI) of at least 30 kg/m^2, computed from respondents' reports of their height and weight. Cigarette smoking was defined based on reports of ever having smoked cigarettes. Diabetes, high cholesterol, and hypertension were based on respondents' reporting ever having been diagnosed with the condition by a health professional. Diabetes excluded gestational diabetes. In addition to examining each of the five risk factors separately, we examined the role of the presence of at least one risk factor (which we term "1+ risk factor").

ANALYTIC APPROACH Our goal was to use a preventable fraction framework to estimate the percentage of disability at the national and state levels that could hypothetically be prevented if risk factors were reduced under two separate target scenarios: complete elimination or reduction in all states to the lowest levels observed in the states in 2013.[30] We term the first scenario the "elimination scenario" and the second the "reduction scenario." The elimination scenario uses a risk-factor prevalence of 0 percent, the theoretical minimum exposure, as the target prevalence.[31] The reduction scenario uses as a target the mean prevalence in the five states that had the lowest prevalence of the risk factor under investigation in 2013.

The analysis proceeded in three stages. First, we estimated the prevalence of disability and each of the risk factors, including the 1+ risk factor measure, in the BRFSS sample at the national and state levels.

Second, we used prevalence ratios to estimate the magnitude of the association between each risk factor and disability. Prevalence ratios, analogous to odds ratios, reflect the ratio of the prevalence of disability among individuals with a risk factor relative to that among individuals without that risk factor. We used multivariable Poisson regression models with robust variance estimation to estimate the prevalence ratios.[32] To allow the prevalence ratios to vary by sociodemographic groups, we estimated models strat-

ified by age range (ages 18–54, 55–64, and 65–79), sex (men and women), and race (non-Hispanic white, Hispanic, and non-Hispanic nonwhite). We controlled for age in single years, educational attainment (less than high school, high school diploma or some college, and college degree or beyond), and depression (whether the respondent had ever been told that she or he had a depressive disorder). These covariates were included as expected confounders of the association between the risk factors and disability.

We also allowed for regional variations in the prevalence ratios through interaction terms between US regions (South, Midwest, East, and West) and the risk factors. In the statistical models, we controlled for the other nonindex risk factors (that is, those not under investigation for a particular model) but avoided overadjustment for risk factors that were consequences of the index risk factor (for example, models that estimated the prevalence ratio associated with obesity excluded an adjustment for diabetes, because diabetes may be on the causal pathway between obesity and disability).

Third, we estimated preventable fractions. We did so by combining information on the prevalence of each risk factor, the preventable fraction associated with each risk factor, and the target prevalence based on the two scenarios: elimination and reduction. The target prevalence for the elimination scenario was set to 0 (indicating a 0 percent prevalence), and for the reduction scenario, it was set to the mean prevalence in the five states with lowest prevalence of the risk factor.

Preventable fractions were estimated within age-sex-race combinations and scaled up to the state and national levels using the weighted-sum approach. For additional details regarding implementation of the weighted-sum approach see the "Detailed Method" section of the online Appendix.[33]

Ninety-five percent confidence intervals for the preventable fractions were estimated using Monte Carlo simulations and accounted for the sampling error in both prevalence and prevalence ratio estimation.[34] BRFSS-provided survey weights were incorporated into all estimations. Tests of significance were performed ($\alpha = 0.05$). Details about our procedures are in the "Detailed Method" section of the Appendix.[33]

LIMITATIONS The main limitation of our study was the use of self-reported risk-factor data. Studies report that up to 36 percent of people in the United States with diabetes and 20 percent of those with hypertension are undiagnosed,[35,36] and obesity is underestimated using self-reported data.[37] Therefore, the prevalence estimates that we relied on may be conservative (that is, underestimates).

Policies aimed at behavioral change appear the most promising for simultaneously preventing multiple risk factors.

The cross-sectional observational study design also limited a purely causal interpretation of the estimates. We did not examine respondents' physical inactivity, which is an important health risk, because of the high potential for reverse causality—that is, the possibility that disability status determined activity levels, instead of vice versa.

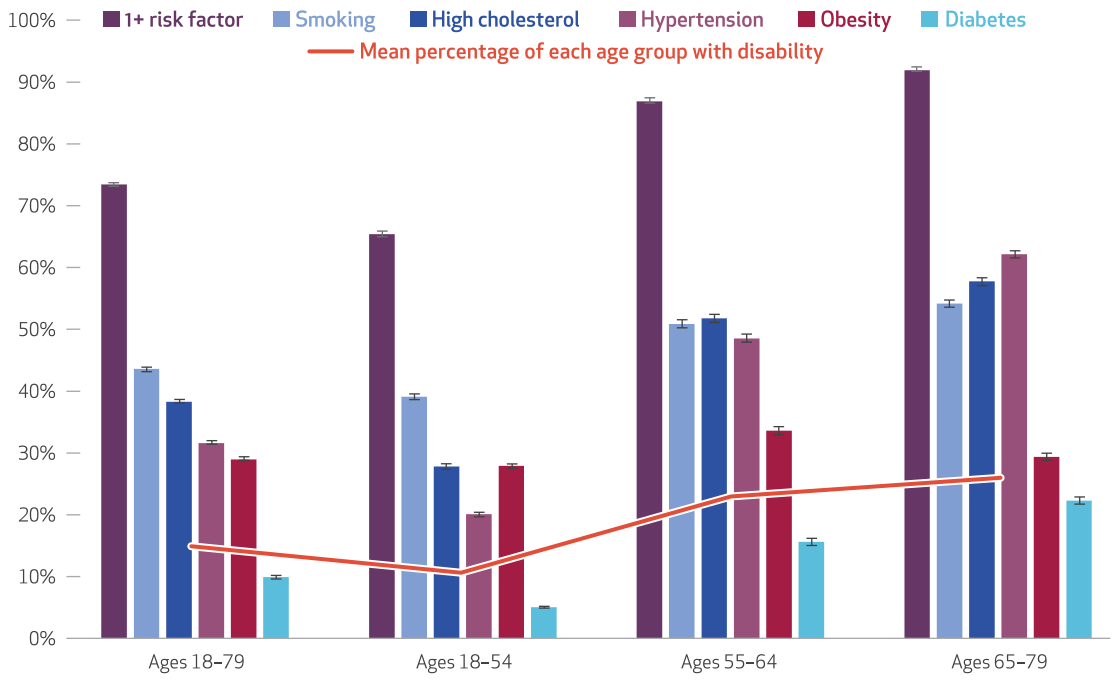
Study Results

DESCRIPTIVE CHARACTERISTICS OF THE SAMPLE Fifteen percent of adults ages 18–79 reported having a disability (Exhibit 1). As expected, disability prevalence increased with age: Approximately 11 percent of those ages 18–54 and 26 percent of those ages 65–79 reported having a disability. At all ages, women reported higher levels of disability, compared to men (Appendix Exhibit 1).[33] Seventy-three percent of adults ages 18-79 reported having at least one risk factor (Exhibit 1). "Ever smoking" was the most common risk factor, reported by 44 percent of the entire sample of adults. The prevalence of all of the risk factors was higher at older than at younger ages with the exception of obesity, which was lower among those ages 65–79 (reported by 30 percent) than among those ages 55–64 (34 percent). Sex-specific estimates and standard errors for the descriptive characteristics are presented in Appendix Exhibit 1.[33]

PREVALENCE RATIOS Prevalence ratios indicate the relative prevalence of disability among those with a given risk factor, compared to among those without the risk factor. Appendix Exhibit 2[33] shows the prevalence ratios among people ages 50–64 for illustrative purposes. Prevalence ratios for other age groups are available upon request from the corresponding author. Adults with at least one risk factor (1+ risk factor) had

EXHIBIT 1

Percentages of US adults with disability and risk factors, by age group, 2013



SOURCE Authors' analysis of data for 2013 from the Behavioral Risk Factor Surveillance System. **NOTES** Disability (the trend line) is reported having serious difficulty walking or climbing stairs, having difficulty dressing or bathing, or having difficulty doing alone errands such as visiting a doctor's office or shopping. "1+ risk factor" indicates the presence of at least one risk factor. Smoking refers to ever having smoked cigarettes. Obesity is a body mass index of 30 kg/m^2 or higher based on self-reported height and weight. Hypertension, diabetes (excluding gestational diabetes), and high cholesterol are based on having ever been diagnosed with the condition. The estimates reflect sample weighting. Error bars represent 95 percent confidence intervals.

about three times the prevalence of disability as those with no risk factors (Appendix Exhibit 3).[33] Among the individual risk factors, obesity and diabetes had the highest prevalence ratios, ranging from about 1.4 to 1.8—which indicates a 40–80 percent higher disability prevalence among those with these risk factors than among those without it. Having high cholesterol was not associated with a significantly increased disability risk. In general, the prevalence ratios did not differ significantly by geographic region.

NATIONAL PREVENTABLE FRACTIONS In the scenario with elimination as the target, the preventable fraction for the 1+ risk factor measure was 53 percent among adults ages 18–79 (Exhibit 2). In other words, if everyone in this age group had no risk factors, we would expect the prevalence of disability for the group to be reduced by 53 percent.

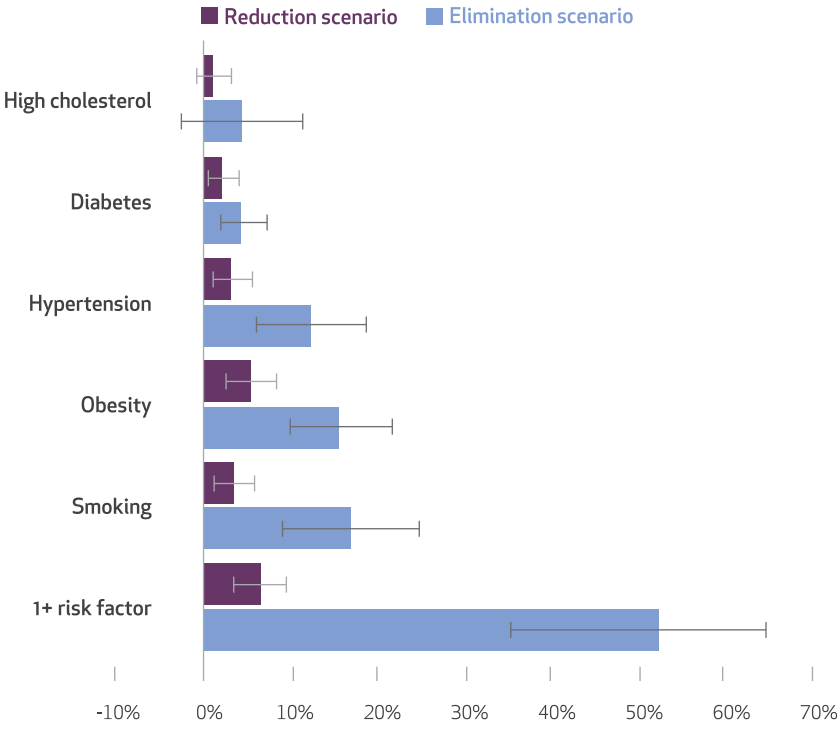
The preventable fraction did not differ significantly between men (53 percent) and women (52 percent) in this age group (Appendix Exhibit 3). The preventable fraction for the 1+ risk factor measure also did not significantly differ by age group (ages 18–54, 55–64, and 65–79) (Appendix Exhibit 3).[33] However, the point estimate for preventable fractions for the 1+ risk factor was higher at older ages, reaching 57 percent for men and 64 percent for women ages 65–79, compared with 49 percent and 47 percent, respectively, for those ages 18–54 (Appendix Exhibit 3).[33] For all people ages 18–79, smoking had the highest preventable fraction of the individual risk factors, followed by obesity (Exhibit 2).

In the scenario with reduction as the target, the national preventable fraction of disability associated with the 1+ risk factor measure for all adults ages 18–79 was 7 percent (Exhibit 2). That is, we would expect the prevalence of disability for that group of people to be reduced by 7 percent if all states had the same percentage of individuals with 1+ risk factor as the five states that had the lowest prevalence of this measure in 2013. In the reduction scenario, obesity was the individual risk factor with the highest preventable fraction.

The Appendix shows preventable fractions and associated 95 percent confidence intervals in table form by sex and age group for the elimination (Appendix Exhibit 3) and reduction (Appendix Exhibit 4) scenarios.[33]

EXHIBIT 2

Preventable fractions of disability if risk factors were eliminated or reduced for adults ages 18–79, 2013



SOURCE Authors' analysis of data for 2013 from the Behavioral Risk Factor Surveillance System. **NOTES** The elimination scenario uses a risk-factor prevalence of 0 percent. The reduction scenario uses the mean prevalence in the five states with the lowest prevalence of a given risk factor. High cholesterol, diabetes, hypertension, obesity, smoking, and 1+ risk factor are defined in the Notes to Exhibit 1. The estimates reflect sample weighting. Error bars represent 95 percent confidence intervals.

State-Level Findings

We next examined age- and sex-adjusted disability prevalence in quintiles by state (Exhibit 3). Disability prevalence was generally highest in the South and lowest in the Great Plains states. In general, the states with the lowest risk-factor prevalence were in the West and Northeast, while the states with the highest risk-factor prevalence were in the Midwest (Appendix Exhibit 5).[33] Utah (60 percent) and California (67 percent) had the lowest percentages of individuals with 1+ risk factor—meaning that they had the highest percentages of people without any of the risk factors. Utah is noteworthy for ranking lowest in prevalence for three of the five risk factors (smoking, high cholesterol, and hypertension). Kentucky (82 percent) and West Virginia (83 percent) had the highest percentages of people with 1+ risk factor. Both of those states were also generally ranked as having the highest prevalence of each of the individual risk factors.

States varied widely in their preventable fractions of disability (Exhibit 4). In general, states in the South and Midwest had the highest fractions, and states in the West and Northeast had the lowest. The lowest state-level preventable fraction was 37 percent (Utah), and the highest was 66 percent (South Dakota). The online Appendix lists the state-level preventable fractions and 95 percent confidence intervals for the elimination (Appendix Exhibit 6) and reduction (Appendix Exhibit 7) scenarios for all risk factors.[33]

Discussion

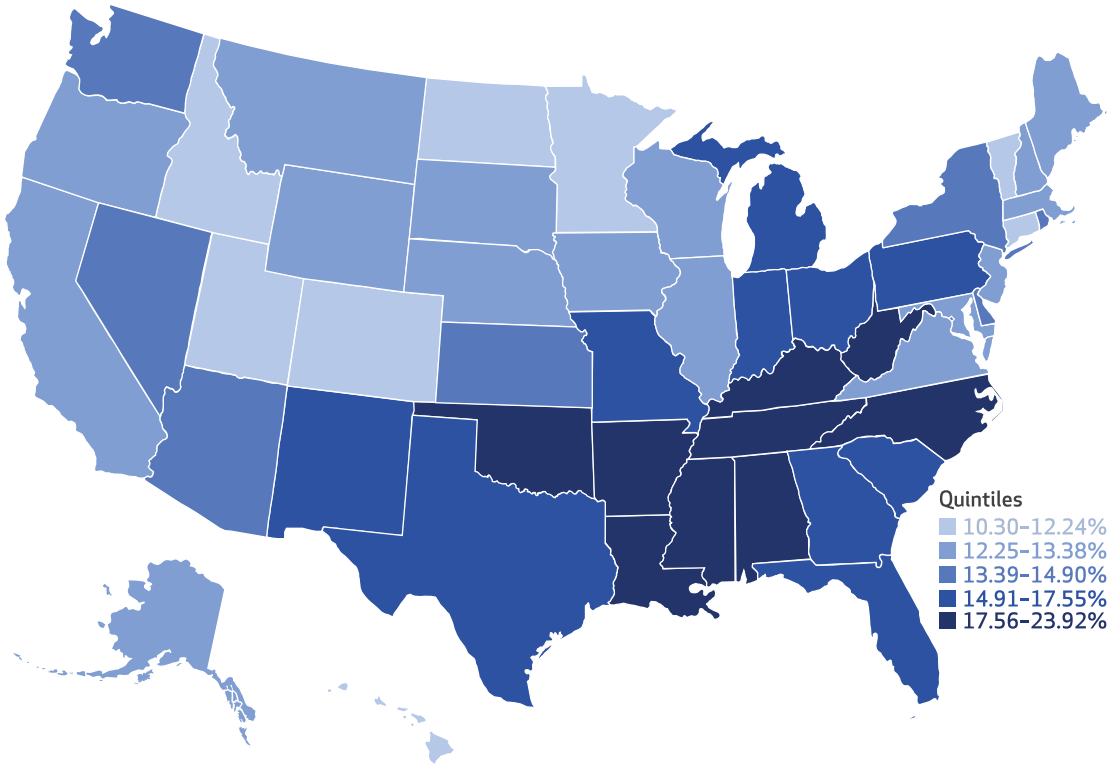
Comparative assessments of major modifiable risk factors aid in prioritizing public health targets for intervention.[31] Results from this study specifically indicate the population-level role played by modifiable, lifestyle-related risk factors in shaping aggregate US disability levels. To our knowledge, this work is the first to quantify the individual and cumulative burden of modifiable risk factors in terms of disability levels in the United States. We found that approximately half of the disability prevalence among US adults in 2013 could be attributed to the presence of at least one of five major modifiable risk factors. Of the individual risk factors, smoking, obesity, and hypertension—in that order—were the most consequential.

Although the complete elimination of a particular risk factor from the population is the conventional target for calculating preventable fractions, as a more realistic scenario we also considered as a target the prevalence of risk factors achieved in states with the lowest prevalence.[30] This target provides a more realistic assessment of disability reductions achievable through health policy. If all states were to reduce risk-factor prevalence to the levels observed in the best states, we would expect national disability reductions of up to 7 percent, with the largest expected reduction in disability from reducing national obesity prevalence to the lowest observed prevalence in states in 2013.

With respect to the interpretations of the preventable fractions, it is important to note that certain risk factors are on the causal pathway between other risk factors and disability. Smoking and obesity influence the risk of diabetes, high cholesterol, and hypertension. The preventable fractions we estimated reflect these relationships, and our approach did not partial out the various pathways. For example, the preventable fraction associated with obesity reflected both the effects of obesity on disability independent of diabetes, hypertension, and high cholesterol and the indirect effects of obesity on disability that operate through the other three risk factors. Similarly, the preventable fraction associated with smoking incorporated both estimated direct and indirect effects of smoking on disability.

EXHIBIT 3

States by quintiles of disability prevalence among adults ages 18–79, 2013



SOURCE Authors' analysis of data for 2013 from the Behavioral Risk Factor Surveillance System. **NOTES** Prevalence of disability (defined in the Notes to Exhibit 1) was age- and sex-standardized to the US population ages 18–79 in 2013. The estimates reflect sample weighting.

It is therefore incorrect to add the preventable fractions across the various risk factors. In addition, the preventable fractions for smoking did not differentiate between effects of current and of former smoking.

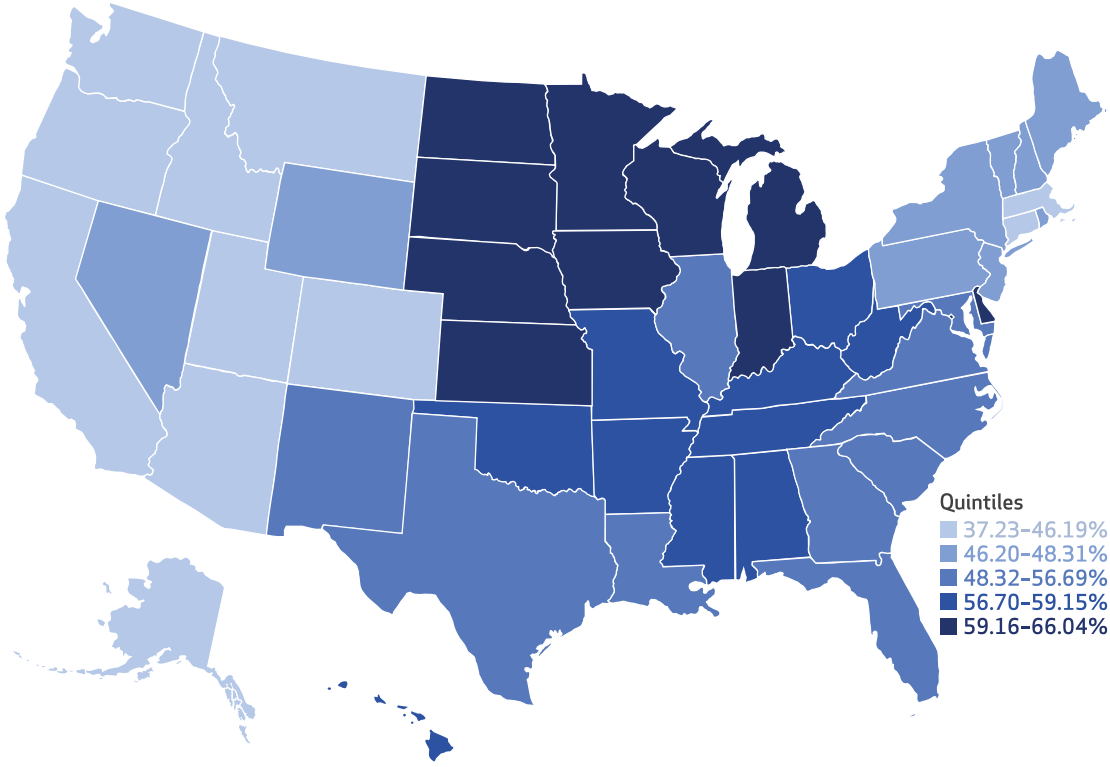
Our study examined the contribution of the risk factors to disability levels in 2013. According to the preventable fraction metric, the two most important risk factors in terms of largest contribution to disability were smoking and obesity. Given continued declines in smoking levels among US adults[38] and a persistently high prevalence of obesity,[39] especially at increasingly younger ages, it is conceivable that in the near future, obesity will surpass smoking as the single most important risk factor for disability in the United States.

While our study did not assess trends, previous research has implicated obesity's role in rising disability levels. A 2004 study indicated that obesity explained about one-quarter of the growth in disability, measured through limitations in the ability to perform personal care tasks, among people ages 30–39 and one-tenth of the growth among those ages 40–49 in the period 1984–96.[9] A 2014 study indicated that increasing BMI among people ages 40–64 explained nearly all of the increase in disability in this age group, measured by physical functioning and IADLs, in the period 1997–2010.[40]

Relative to the other risk factors, we found that diabetes was associated with small preventable fractions. This finding should not be interpreted as showing that diabetes is an unimportant determinant of disability for individuals or populations. In fact, we found the association between diabetes and disability to be as high as or higher than was the case with the other risk factors (see, for example, the prevalence ratios in Appendix Exhibit 2).[33] This finding underscores the high risk of disability associated with having diabetes. The relatively small preventable fractions for diabetes were largely a function of its lower prevalence compared to the other risk factors in the age range we examined (ages 18–79). For example, approximately 10 percent of adults in that age group reported having been diagnosed with diabetes, compared to roughly 30 percent or more for each of the other risk factors. The prevalence of diabetes rises sharply with age, and

EXHIBIT 4

States by quintiles of preventable fractions of disability for adults ages 18–79, 2013



SOURCE Authors' analysis of data for 2013 from the Behavioral Risk Factor Surveillance System. **NOTES** Disability is defined in the Notes to Exhibit 1. Estimates reflect percentage reduction in disability if no people in each state had any of the five risk factors (smoking, high cholesterol, hypertension, obesity, diabetes). The estimates reflect sample weighting.

analyses limited to older populations (those ages 65 and older) might reveal much larger preventable fractions associated with diabetes than our study did. The CDC estimated that approximately one-quarter of adults ages 65 and older had diabetes, including undiagnosed cases.[41]

Also concerning is the fact that among hypertension, high cholesterol, and diabetes, the secular trends for diabetes appear to be the most unfavorable. Between 1960 and 2000, diabetes was the only risk factor that increased in prevalence among adults ages twenty and older, with measured high blood pressure and high cholesterol levels showing substantial declines.[42] The increasing prevalence of diabetes over time appears to be attributable to the increasing prevalence of obesity over time.[43] If recent patterns continue into the future, the preventable fractions associated with obesity and diabetes will likely increase.

While cigarette smoking is itself a behavior, the four metabolic risk factors (diabetes, obesity, hypertension, and high cholesterol) have common behavioral antecedents—notably, poor diet, low levels of physical activity, and smoking.[44,45] Policies aimed at behavioral change therefore appear to be the most promising for simultaneously preventing multiple risk factors.

What types of policies would be most effective? Levels of cigarette smoking have fallen since the 1960s, a decline that has been attributed in large measure to aggressive taxation and national-level health communication campaigns.[46,47] There are several ongoing populationwide campaigns to reduce risk-factor prevalence: state-level taxation of sugar-sweetened beverages,[48] steps taken by the Food and Drug Administration to limit trans fats in processed foods,[49] state policies promoting school-based physical activity,[50] and employer-based wellness programs that incentivize preventive health care and healthy lifestyle. Other large-scale programs, such as the CDC's National Diabetes Prevention Program, focus on high-risk individuals and target them for lifestyle interventions. However, scientific consensus is lacking on the set of policies that are most successful in improving the dietary and physical profile of the US population.[51–53]

Disability levels in the United States were high-

est in the South, the Appalachian region, and states near the Great Lakes. Our estimates suggest that many states in these regions would experience the largest proportionate declines in disability—often in excess of 10 percent—if they reduced risk-factor levels to those occurring in the states with the lowest prevalence of risk factors. Relative to other regions, these regions also have relatively high death rates[54] and low life expectancy,[55] high prevalence of risk factors,[30,56–58] poor detection and control of risk factors,[56] and high levels of poverty.[59] These burdens, combined with socioeconomic deprivation, also make these states some of the most challenging for policy intervention.

The validity of the preventable fractions reported here depends in large measure on the validity of the estimated prevalence ratios of disability. Despite reliance on cross-sectional associations, the rank order and magnitude of prevalence ratios we relied on were largely consistent with measures of associations found in prospective studies. A recent study of the Framingham offspring cohort identified smoking, obesity, and diabetes as the main predictors for disability, defined using an ADL measure, in adults ages 45–65 at baseline.[60] In a finding similar to our results, cholesterol was not as salient a predictor of disability as these other risk factors. Similarly, our estimates for diabetes were comparable in magnitude to findings from a systematic review of twenty-six studies of the disability risk associated with diabetes.[61]

Conclusion

This analysis provides a benchmark for national and state-level monitoring of disability levels in the US population over time and across regions. Roughly half of the disability burden in the United States in 2013 can be attributed to the presence of risk factors known to be modifiable, with cigarette smoking, obesity, and hypertension contributing the largest share to overall disability. Further understanding of the wide state-level variation in disability and the prevalence of risk factors may also yield important policy insights. ■

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NOTES

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